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AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER, RIVER M--ETC(U)

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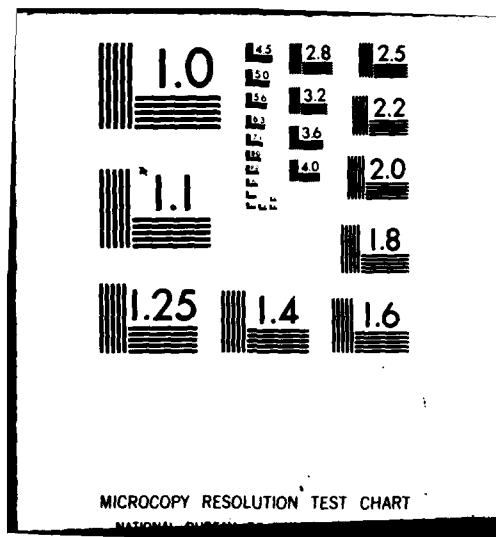
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20. ABSTRACT (Continued).

Although not designed to provide definitive information on riverine ecology, a number of significant observations emerged. From an overall view, dike fields, abandoned channels, temporary secondary channels, and oxbow lakes were found to be extremely valuable habitat. This suggests that sound environmental management should seek to preserve and/or maintain these habitats in navigation projects.

A complete listing of the reports in the series "Aquatic Habitat Studies in the Lower Mississippi River, River Mile 480 to 530" is as follows:

- Report 1: Introduction
- Report 2: Aquatic Habitat Mapping
- Report 3: Benthic Macroinvertebrate Studies--Pilot Report
- Report 4: Diel Periodicity of Benthic Macroinvertebrate Drift
- Report 5: Fish Studies--Pilot Report
- Report 6: Larval Fish Studies--Pilot Report
- Report 7: Management of Ecological Data in Large River Ecosystems
- Report 8: Summary

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## PREFACE

The work described in this report is part of the Environmental and Water Quality Operational Studies (EWQOS), Work Unit VIIB, conducted by the U. S. Army Engineer Waterways Experiment Station (WES) for the Office, Chief of Engineers, U. S. Army. This report is one of a series of eight reports which discusses the results of a pilot study on the Lower Mississippi River, river mile 480 to 530. The pilot study was completed by the Waterways Habitat and Monitoring Group (WHMG), Environmental Systems Division (ESD), Environmental Laboratory (EL), WES.

This report, Report 8 of the series, is a summary. It includes information on sampling, experimental design, data management, and initial ecological observations of fish and benthic invertebrates in a number of riverine habitats. For detailed information, the reader is referred to that particular report covering the subject of interest.

The report was prepared by Dr. Thomas D. Wright, Chief, WHMG, under the supervision of Mr. Bob O. Benn, Chief, ESD, Dr. Jerome L. Mahloch, Program Manager, EWQOS, and Dr. John Harrison, Chief, EL.

COL John L. Cannon, CE, was Commander and Director of WES during field conduct of this study. COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE, were Commanders and Directors of WES during preparation of this report. Mr. Fred R. Brown was Technical Director of WES.

This report should be cited as follows:

Wright, T. D. 1982. "Aquatic Habitat Studies on the Lower Mississippi River, River Mile 480 to 530; Report 8, Summary," Miscellaneous Paper E-80-1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
acres	4046.873	square metres
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
miles (U. S. statute)	1.609347	kilometres

AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER,  
RIVER MILE 480 TO 530

SUMMARY

PART I: INTRODUCTION

Background

1. The U. S. Army Engineer Waterways Experiment Station (WES) is conducting a nationwide program of applied research to solve selected environmental quality problems associated with Civil Works activities of the U. S. Army Corps of Engineers (CE). The study is sponsored by the Office, Chief of Engineers, and is entitled the Environmental and Water Quality Operational Studies (EWQOS).

2. During the early planning phase of EWQOS, visits by WES personnel were made to each Corps Division office in the United States to identify and assess the magnitude of environmental quality problems associated with CE water resource projects. Areas of interest to the field offices concerned reservoirs and large rivers and involved data collection and interpretation, assessment of existing chemical and biological conditions, and determination of project impacts. One study area of high priority involved the many activities occurring on major, navigable waterways of the United States. Specifically, the man-made structures that assist in navigation, such as dikes, revetments, and locks, were isolated as problem areas where little information on environmental impacts exists.

3. The waterway field studies, a portion of the EWQOS studies, were designed to evaluate the impacts of navigational structures on fish, benthic (bottom) invertebrates, and water quality in large rivers. Productivity, the effects of high water, and the relationship between slack-water habitats (oxbow lakes and bendway cutoffs) and the nutrient budget of the riverine ecosystem were also investigated. These waterway field studies were conducted on the Mississippi River in Mississippi, and the

Tombigbee River in Alabama and Mississippi. Field work on these two rivers was terminated in FY 80 and reports on the findings are in progress. The data collected will provide specific information on the interaction between aquatic organisms and man-made navigational structures as well as developing environmental considerations for the design and location of dikes and revetments (Mississippi River) and bendway cutoffs (Tombigbee River).

4. In the early stages of the waterway field studies, a preliminary survey, or pilot study, was undertaken on the Lower Mississippi River (Figure 1). This initial survey, conducted from April to October, 1978, was to evaluate sample methods, to identify habitats and navigational structures for more detailed studies on the Mississippi and other rivers, and to develop an initial understanding of the complexities of large river habitats.

#### Purpose and Scope

5. The goal of the waterway field studies on the Lower Mississippi River was to assess the ecological significance of navigational structures in major rivers. Information developed from the study will be used to formulate environmental guidelines for the design of new dikes, dike fields, and revetted banks or the modification of these existing navigational structures.

6. The waterway field studies were to clarify the biological characteristics of both natural habitats (sandbars, abandoned channels, natural banks, etc.) and man-made habitats (dikes, dike fields, and revetted banks) in the Lower Mississippi River. Specific objectives were:

- a. To quantitatively define effects of the age, size, and building materials of dikes and revetments on hydrologic characteristics of the river.
- b. To describe the physicochemical characteristics of both natural and man-made habitats in the river. Significant parameters include water depth, flow, sediment size, major cations and anions, dissolved oxygen, specific conductance, and water temperature.

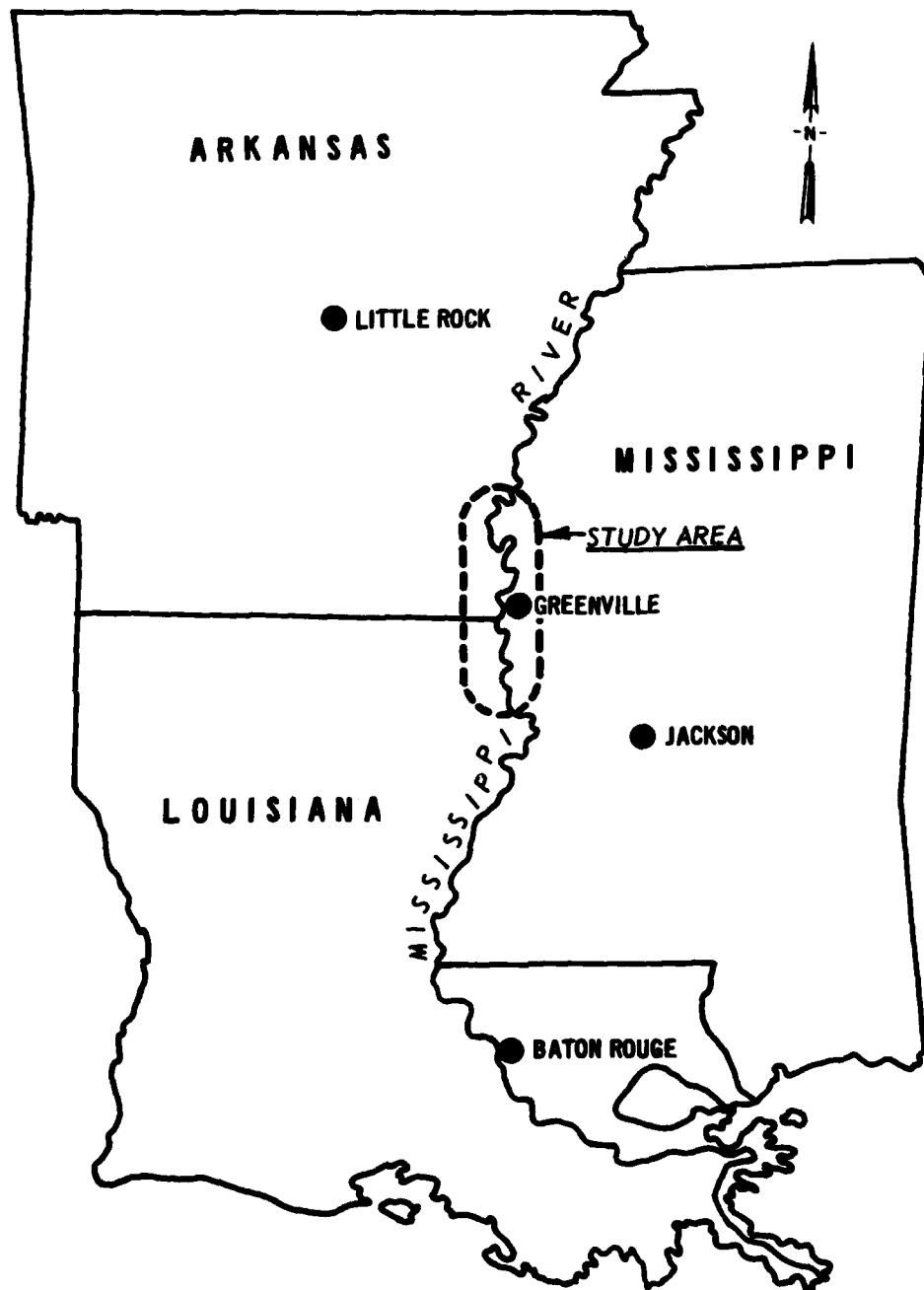


Figure 1. General location of pilot investigation from river mile 480 to 530 in the vicinity of Greenville, Mississippi

- c. To provide qualitative and quantitative information on phytoplankton, zooplankton, particulate organic matter, and detritus associated with the various habitat types.
- d. To identify the abundance and distribution of benthic organisms associated with the habitat types, to calculate species diversity, and to describe utilization of the various habitat types by all species.
- e. To define the species diversity, abundance, and distribution of fish in the Lower Mississippi River and to examine the various habitat types used for spawning, feeding, and nursery areas.

7. As part of the overall goal, a pilot survey was conducted from April to October, 1978. Results of this study were used to design the planned major habitat analysis of the Lower Mississippi River (1979-1980). The seven-month pilot survey provided:

- a. Data on currents, sediments, bathymetry, river stage, and shoreline vegetation.
- b. An evaluation of the most efficient sampling techniques for biological and physicochemical data in the various habitats.
- c. Baseline biological, physical, and chemical data for designing the sampling program for the intensive field studies.
- d. A basis for further studies on the Lower Mississippi River and other large navigable rivers as a part of the EQQS Program.

8. As noted, the pilot survey was not designed or expected to provide definitive information or lead to conclusions concerning the waterway environment. However, analysis of data obtained during the pilot investigation has led to a number of preliminary conclusions which will be verified or rejected through data obtained during the subsequent studies. These preliminary findings have provided a basis for the series of reports listed below:

- Report 1: Introduction
- Report 2: Aquatic Habitat Mapping
- Report 3: Benthic Macroinvertebrate Studies--Pilot Report
- Report 4: Diel Periodicity of Benthic Macroinvertebrate Drift
- Report 5: Fish Studies--Pilot Report

Report 6: Larval Fish Studies--Pilot Report

Report 7: Management of Ecological Data in Large River Ecosystems

Report 8: Summary

9. The purpose of this report (Report 8) is to summarize the findings of Reports 2-7. Report 1 (Introduction) has been effectively summarized in the introductory section of this report. For brevity, references will not be included in this report; the reader is referred to the individual reports for references and/or detailed information.

## PART II: FINDINGS

### Report 2: Aquatic Habitat Mapping

10. The initial step in the pilot investigation was the mapping of aquatic habitats within the study reach. This mapping was required because of the need to stratify the sampling effort on the basis of existing habitats. In high-order streams, the large and complex geomorphology adds emphasis and distinction to the many habitats that are present.

11. Aquatic habitats were mapped in a 50-mile\* reach of the Lower Mississippi River (Figure 2) between Lake Providence, Louisiana, and Greenville, Mississippi (river mile 480 to 530 Above Head of Passes (AHP)). This reach encompasses two major bendway systems, Kentucky Bend and Opossum Chute. The river in the study area vicinity (Vicksburg, Mississippi, river mile 437) has an average discharge of about 561,000 cfs and may fluctuate as much as 40 ft in stage annually. A 50-mile study reach was selected to obtain a realistic estimate of the average relative abundance of aquatic habitat types. Mapping a reach that was too short could result in a bias of spatial relationships among habitats if one large, but relatively uncommon habitat type (such as a large oxbow lake) occurred in the reach.

12. The first step in habitat mapping was defining aquatic habitat types in a specific manner that could provide quantitative acreage measurements and that had ecological meaning. The classification system developed was based on a synthesis of ecological and basic river hydraulic considerations. For example, the distinction between a shallow water sandbar habitat and the adjacent main channel is clear from an ecological standpoint; however, the boundary between the two habitats was defined in terms of the hydraulic concepts of the main channel.

13. The mapping effort included all aquatic habitats within the

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\* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

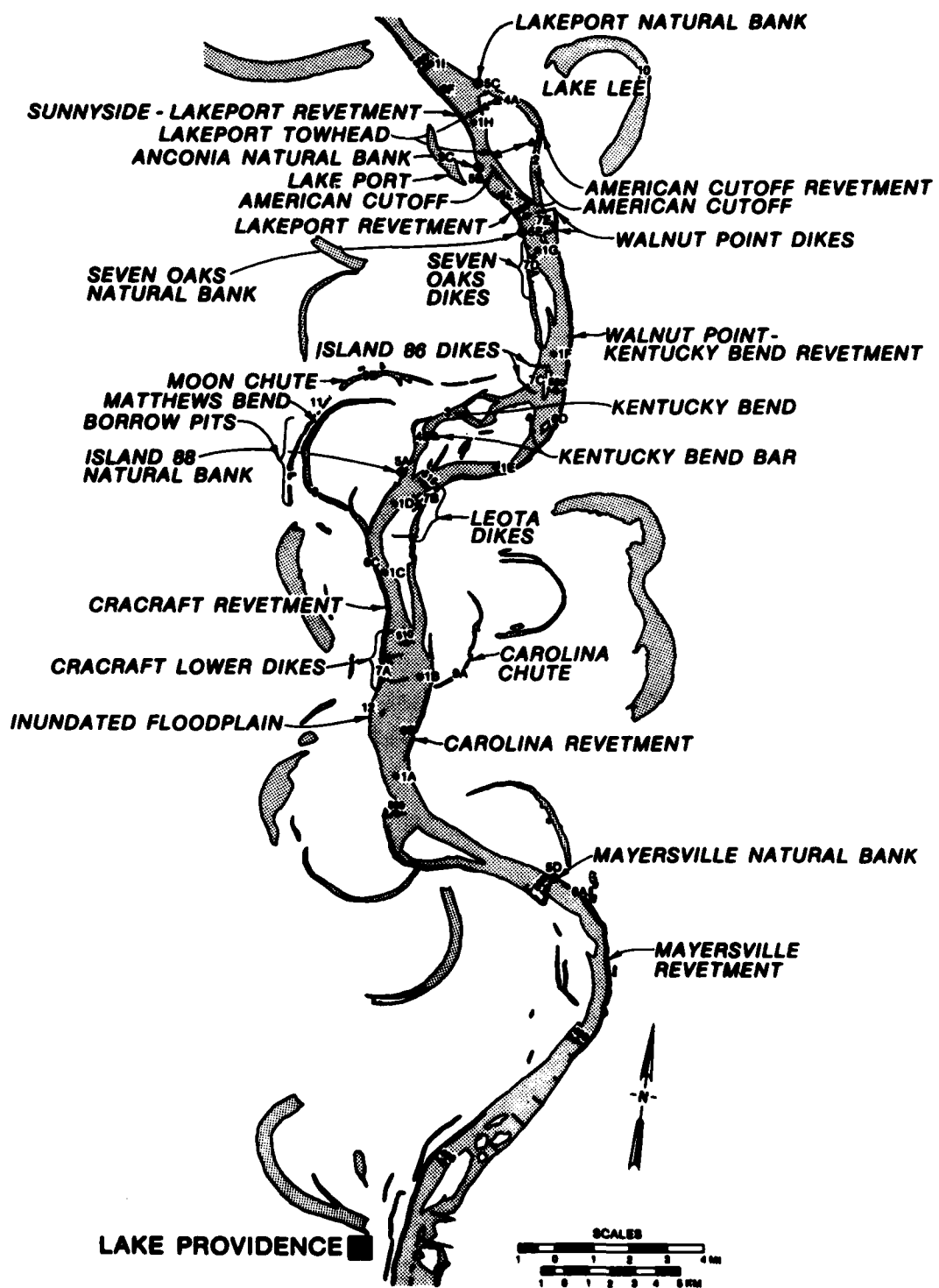


Figure 2. Study area



leveed floodplain. Although some habitats are isolated from the main channel during low flow conditions, they become confluent with the channel and are integral parts of the overall system during periods of overbank flow. Twelve major habitats were identified and their areal extents determined at low, medium, and overbank flow levels. The discharge at these levels was, respectively,  $1.4 \times 10^5$ ,  $4.0 \times 10^5$ , and  $8.7 \times 10^5$  cfs. The habitats and their absolute and relative surface acreages are given in Table 1, and are schematically portrayed in Figure 3.

14. The 50-mile study reach that was mapped for the pilot studies was found to contain 372 acres per river mile at low stages and 580 acres per river mile at medium flow (Table 1). These values were

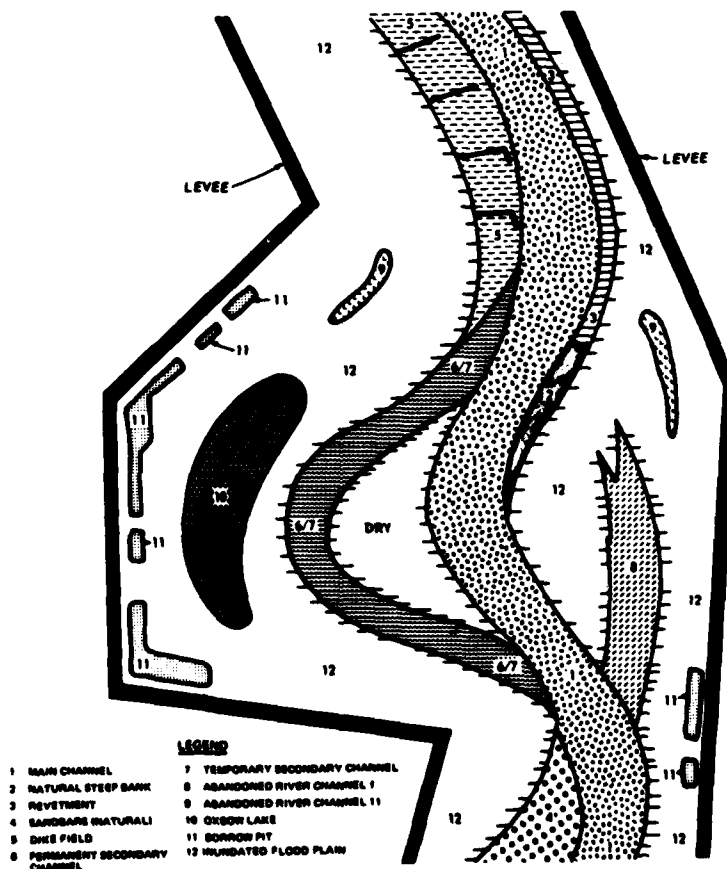


Figure 3. Schematic drawing of habitats sampled in Lower Mississippi River, 1978

compared to those of a 98-mile reach of the Upper Mississippi and the Lower Mississippi from Memphis, Tennessee, to Baton Rouge, Louisiana. Although the specific criteria and habitats were somewhat different from those of the pilot study, 487 acres of aquatic habitat per river mile and 540 acres of aquatic habitat per river mile, respectively, were reported in the two studies. Thus, it appears that the techniques and criteria employed in the pilot study yielded satisfactorily representative results.

15. The habitat mapping results proved useful in designing the subsequent EWQOS field studies on the Lower Mississippi River, and the habitat mapping technique used appears to be a viable technique for stratifying the ecosystem on any large alluvial river to design ecological field sampling programs. Data on habitat acreages and changes in habitat sizes with river stage and discharge are beneficial in quantifying study results, especially studies of benthic communities. The acreage data combined with benthic standing crop data were found to be useful in distinguishing the key habitats of the river in terms of potential benthic production. In general, habitat maps can provide a valuable framework for the portrayal and interpretation of data from aquatic habitat surveys and investigations in large river systems.

16. The aquatic habitat mapping approach appears directly applicable to evaluating project-related impacts using habitat evaluation methods. Aquatic habitat maps of waterways could be used to establish existing and future with- and without-project conditions for various planning activities. The data could also be applied to riverine systems as land-use data are applied to evaluate terrestrial impacts of a water resource development project.

### Report 3: Benthic Macroinvertebrate Studies--Pilot Report

17. In order to perform benthic macroinvertebrate sampling, nine aquatic habitat types within the leveed 50-mile study area were first identified. These included dike field, dike structure, revetted bank, natural bank, abandoned channel, permanent secondary channel, temporary

secondary channel, main channel, and sandbar habitats. The inundated floodplain habitat was not sampled for benthic macroinvertebrates.

18. A variety of sampling devices/techniques were evaluated. It was found that, to obtain a satisfactory reduction in sample variance, stratified random sampling was required in dike fields. Replicated subsamples were adequate in other habitats, with the exception of revetted banks. Gear evaluations included inlaid samplers and Ponar, petite Ponar, and Shipek grabs. The gear evaluations were designed to select those devices that would provide the most representative samples from a particular habitat. Inlaid samplers proved to be the most satisfactory for dike structures, but equivocal results were obtained from the grab samplers. Hence, a separate study was conducted to evaluate the petite Ponar and the Shipek by using the standard Ponar as a reference.

19. Samplers having a large sampling area were found to be best suited for descriptive sampling such as assemblage composition and structure for fishfood availability studies. The data indicated that with careful attention to minimize shock-wave effects, the Shipek was most suitable for high-energy habitats such as natural banks, dike fields, and the main channel during high flow.

20. The petite Ponar grab was recommended for comparative studies in depositional habitats such as abandoned channels and dike fields at low flow because the organisms in these environments have a highly contagious distribution. The smaller sampler allows for increased replication at a station while minimizing laboratory processing time for each sample.

21. No completely adequate technique was developed for revetted banks. In the study area, the revetment material is articulated concrete mattress (ACM). No surficial sediment is present on the ACM; however, organisms are present on the surface and in the underlying sediment. Efforts are continuing to determine satisfactory quantitative and qualitative sampling methods on this habitat.

22. The dike field benthic macroinvertebrate assemblage was characterized by a diverse variety of both lotic- and lentic-adapted taxa. The oligochaete Limnodrilus spp. was numerically the most

abundant taxon collected and was collected in 26 percent of the total grab samples obtained from the four dike field sites. The burrowing mayfly Tortopus incertus was numerically the second most abundant taxon collected. Although this taxon accounted for a significant percentage of the total dike field sample density, it was only collected in 8 percent of the 220 grab samples obtained from the four dike field sites. The burrowing mayfly Pentagenia vittigera and the pelecypod Corbicula fluminea were the only remaining taxa that were frequently collected from the four dike field sites, but characteristically at low levels of abundance. Each was collected from all four sites.

23. The overall average sample density of macroinvertebrates collected from the four dike field sites was 7.4 organisms/0.05 m<sup>2</sup>, and ranged from a minimum of 0.9 organisms/0.05 m<sup>2</sup> to a maximum of 16.6 organisms/0.05 m<sup>2</sup>. Thirty-two distinct taxa were collected from the four dike field sites. The number of distinct taxa collected from each dike field ranged from a minimum of 7 total taxa to a maximum of 23 total taxa. The average overall number of taxa collected per sample was 0.9 taxa/0.05 m<sup>2</sup> and ranged from a minimum of 0.6 taxa/0.05 m<sup>2</sup> to a maximum of 1.5 taxa/0.05 m<sup>2</sup>.

24. The mixed lotic- and lentic-adapted composition of the taxa collected from these dike fields indicates that their origin is primarily from main channel drift and that a characteristically distinct macroinfaunal assemblage did not occur within this aquatic habitat under the river conditions sampled. However, the high number of distinct macroinvertebrate taxa (32) collected from these sites (second only to the abandoned channel habitats with 39 distinct taxa) indicates that these dike fields are effective collectors of macroinvertebrate drift. Additionally, because of the abundance of lentic-adapted taxa in these samples, certain of these dike fields may also serve as effective extensions of the abandoned channel during low flow and dike pool formation when the majority of the abandoned channels are totally isolated from the main channel ecosystem.

25. From the 20 individual rock samples (not inlaid samplers) taken from dike structures, the net-spinning caddisflies Hydropsyche spp.

were by far the most abundant taxon collected, representing 86 percent of the total sample density. The tube-building dipteran larvae Rheotanytarsus sp. and Polypedilum sp. were the next most abundant taxa collected, representing 5 percent and 4 percent of the total sample density, respectively. The net-spinning caddisfly Potamyia flava and the clinging mayflies Baetis sp., Stenonema integrum, and Heptagenia marginalis were frequently collected from the individual stone samples and characteristically at low levels of abundance. The average total density of benthic macroinvertebrates collected from the 20 substrate samples was 536.4 organisms/rock sample. Taxa averaged 7.3 per rock sample.

26. It can be seen that the caddisfly Hydropsyche spp. was by far the dominant taxon collected. Although only the dike surface substrate was sampled during the pilot study, field observations indicated that highest macroinvertebrate densities (primarily tube-building chironomids and caddisflies) were associated with the surface substrate. Field observations also indicated that significant macroinvertebrate activity occurs much deeper within the dike structure; thus, the data obtained during this effort may not totally reflect actual assemblage composition and structure. As evidenced by the high average benthic macroinvertebrate densities (536.4 organisms/rock sample) and diversity (7.3 taxa/rock sample) obtained from these samples, dike structures appear to provide a highly productive habitat for primarily lotic-adapted benthic macroinvertebrates. Based on data obtained from natural banks, the macroinvertebrate assemblage associated with these dike structures is similar to that associated with the solid, stable substrates provided by submerged trees, snags, and clumps of grass frequently found along the bank line of natural banks. However, the dike structure assemblage appears to be more diverse in composition, possibly due to the wide diversity of available habitats associated with the stone dike substrate.

27. As noted previously, the use of a grab sampler to sample revetted banks proved to be very unsatisfactory. However, field observation indicated that this habitat appears to be a productive habitat for benthic macroinvertebrates. Remnants of pelecypod shells, hydroptychid caddisfly cases, and larval chironomid tubes are numerous at low

water. These observations were substantiated by the occasional collection of hydropsychid caddisflies and leeches due to the scraping action of the Shipek grab sampler over the surface of the sediment-free revetment structure. Additionally, numerous mayfly burrows were observed at lower water where the revetment mattress had buckled over the underlying cohesive clay substrate. A potential value of this revetment mattress structure is the stabilization of the underlying cohesive clay substrate, which provides a unique habitat, primarily for the burrowing mayflies Tortopus incertus and Pentagenia vittigera. These taxa show a definite substrate preference for firm clay sediments and do not appear to be adaptive with regard to sediment type.

28. The natural bank macroinvertebrate assemblage was characterized by burrowing and clinging forms of insect larvae. Although both lotic and lentic forms were collected, lotic forms dominated in both total density collected and in total number of taxa. The net-spinning caddisflies Hydropsyche spp. were numerically the most abundant taxon collected, representing 43 percent of the total natural bank sample density. This genus was collected in 15 percent of the samples obtained from the five natural banks. Field observations during sampling efforts indicated that the majority of these organisms were collected from stations where clumps of grass and artifacts from tree limbs were collected along with the substrate samples.

29. The burrowing mayflies Tortopus incertus and Pentagenia vittigera were numerically the next most abundant taxa collected, representing 32 percent and 8 percent of the total natural bank sample density, respectively. Tortopus incertus was collected in 43 percent of the total natural bank samples and Pentagenia vittigera was collected in 22 percent of the total samples. These taxa were the numerically codominant infaunal organisms found in the various natural bank bottom sediments and reached their highest densities within the cohesive clay sediments.

30. Other genera that were occasionally collected at most natural bank sites included the net-spinning caddisfly Potamyia flava, the amphipod Gammarus sp., the pelecypod Corbicula fluminea, the oligochaete

Limnodrilus spp., and the chironomid Polypedilum sp.

31. The overall average sample density of benthic macroinvertebrates collected from the five natural bank sites was 9.4 organisms/0.05 m<sup>2</sup> and ranged from a minimum of 0.17 organisms/0.05 m<sup>2</sup> to a maximum of 26.8 organisms/0.05 m<sup>2</sup>. Distinct taxa collected from each site ranged from a minimum of 1 taxon to a maximum of 18 distinct taxa. The average overall number of taxa per sample was 1.4 taxa/0.05 m<sup>2</sup> and ranged from a minimum of 0.17/0.05 m<sup>2</sup> to a maximum of 2.91/0.05 m<sup>2</sup>.

32. The abandoned channel benthic macroinvertebrate assemblage was characterized by various dipteran larvae, fingernail clams, and oligochaetes. Although dominant taxa and assemblage structure differed among the five abandoned channel sites, assemblage composition was, for the most part, similar at each site.

33. Chaoborus punctipennis was the most abundant taxon collected, representing 34 percent of the total abandoned channel sample density. It ranged from a minimum of 11 percent of total sample density to a maximum of 86 percent and was collected in 93 of the 100 total grab samples obtained from the five abandoned channels. The oligochaete Limnodrilus spp. was the second most abundant taxon collected overall and accounted for 25 percent of the total abandoned channel sample density. Limnodrilus spp. was fairly abundant and ranged from a minimum of 6 percent to a maximum of 49 percent. This genus was collected in 79 of the 100 total grab samples obtained from the five abandoned channel sites. The predaceous midge Tanypus stellatus was the third most abundant taxon collected, representing 13 percent of the total abandoned channel sample density. Although T. stellatus was the most abundant taxon collected at one site, it was either totally absent in sample collections from the other sites or present only in very small numbers. This genus was collected in 29 of the 100 total grab samples obtained from the abandoned channel sites.

34. The fingernail clam Sphaerium transversum and the dipteran larvae Coelotanypus scapularis were the only remaining taxa present in significant numbers, representing 12 percent and 11 percent of the overall total sample density, respectively. Sphaerium transversum was

collected in 53 of the 100 total grab samples obtained; Coelotanypus scapularis was collected in 58 of the 100 total samples obtained. Each species was characteristically present at relatively low levels of abundance. Additional macroinvertebrate taxa collected in three or more of these sites which may be considered as characteristic of the abandoned channels included the midges Chironomus spp. and Procladius subletti, Hirudinae, the oligochaete Ilyodrilus sp., and the gastropod Physa hawnii.

35. The overall average macroinvertebrate sample density from the five abandoned channels was 70.04 organisms/0.05 m<sup>2</sup> and ranged from a minimum of 47.6 organisms/0.05 m<sup>2</sup> to a maximum of 94.9 organisms/0.05 m<sup>2</sup>. The total number of distinct taxa collected at each site ranged from a minimum of 14 taxa to a maximum of 23 taxa. Average overall number of taxa per sample was 5.2 taxa/0.05 m<sup>2</sup> and ranged from a minimum of 2.9 taxa/0.05 m<sup>2</sup> to a maximum of 6.9 taxa/0.05 m<sup>2</sup>.

36. Twelve macroinvertebrate grab samples were obtained from a permanent secondary channel with a Shipek grab sampler. Three organisms were collected from the 12 grab samples. These included one specimen each of Tortopus incertus, Corbicula fluminea, and Hydropsyche spp.

37. Twenty-four macroinvertebrate grab samples were obtained from a temporary secondary channel with a Shipek grab sampler. From this effort, 51 organisms, representing 14 distinct taxa, were collected. The average sample density was 2.1 organisms/0.05 m<sup>2</sup>; the average number of taxa was 1.0 per 0.05 m<sup>2</sup>. The most abundant taxa collected included the burrowing mayflies Tortopus incertus, Pentagenia vittigera, and Hexagenia limbata, and the pelecypods Sphaerium transversum and Corbicula fluminea. Oligochaetes and dipteran larvae were also present.

38. Eighteen samples were obtained from the main channel during sampling efforts with a Shipek grab sampler. Nine organisms, representing six distinct taxa, were collected. Taxa collected were a mixture of both lotic- and lentic-adapted organisms, including Limnodrilus spp., Tortopus incertus, Hexagenia limbata, Corbicula fluminea, Baetis sp., and Chernovskia orbiculus.

39. Eight grab samples were obtained from sandbar habitat with a



Shipek grab sampler. From this effort, 12 organisms, representing 7 distinct taxa, were collected. Taxa collected included Chaoborus punctipennis, the pelecypods Corbicula fluminea and Sphaerium transversum, the burrowing mayflies Pentagenia vittigera, Tortopus incertus, and Hexagenia limbata, and the oligochaete Limnodrilus spp.

40. The main channel, secondary channel (permanent and temporary), and sandbar habitats were characterized by a diverse variety of both lotic- and lentic-adapted macroinvertebrate taxa in very low numbers. From the 62 Shipek grab samples obtained from these sites, 75 organisms, representing 16 distinct taxa were collected.

41. From the nine aquatic habitats, a total of 20,565 organisms, representing 72 distinct taxa, 17 orders, and 5 classes of benthic macroinvertebrates were collected. From the 578 Ponar and Shipek grab samples, 9,839 organisms, representing 69 distinct taxa, 15 orders, and 5 classes of benthic macroinvertebrates, were collected. From rock dike structures, 10,726 organisms, representing 28 distinct taxa, 13 orders, and 4 classes of benthic macroinvertebrates, were collected during this sampling effort. Table 2 provides a summary of data obtained from each of the nine aquatic habitat types.

42. The dike structures were the most productive benthic macroinvertebrate habitat sampled. Although the data obtained from these structures are not directly comparable to grab sample data, the high average densities (536.4 organisms/rock sample) and the number of taxa (7.3 taxa/rock sample) collected from these samples are indicative of the habitat associated with these structures during this sampling period. Twenty-eight distinct taxa were collected from the dike structures. The assemblage was predominantly lotic in nature and was distinctly characterized by net-spinning hydropsychid caddisflies, tube-building chironomid larvae, and clinging mayflies. The caddisflies Hydropsyche spp. were by far the most abundant taxon collected, representing 86 percent of the total dike structure sample density.

43. Abandoned channels were the second most productive habitat sampled. The average total sample density obtained from this habitat type was 70.04 organisms/0.05 m<sup>2</sup>; the average number of taxa collected

was 5.2 per 0.05 m<sup>2</sup>. This habitat was characterized by lakelike conditions and unconsolidated silt-clay bottom sediments. Thirty-nine distinct benthic macroinvertebrate taxa were collected from this habitat. The macroinvertebrate assemblage was distinctly lentic in nature and was characterized by various dipteran larvae, fingernail clams, and oligochaetes.

44. Natural banks were the next most productive habitat. The average sample density for this habitat was 9.4 organisms/0.05 m<sup>2</sup>; the average number of taxa was 1.4 per 0.05 m<sup>2</sup>. The benthic macroinvertebrate assemblage was predominantly lotic in nature and was characterized by burrowing and clinging forms of insect larvae. Lentic forms, such as oligochaetes and certain dipteran larvae, were restricted to areas where the deposition of fine-grained sediments and, presumably, benthic drift occurred. The predominant infaunal forms within this habitat were two species of burrowing mayflies, Tortopus incertus and Pentagenia vittigera.

45. Dike fields were characterized by a highly diverse variety of both lotic- and lentic-adapted benthic macroinvertebrate taxa at fairly low levels of abundance. The average total density per sample for this habitat type was 7.4 organisms/0.05 m<sup>2</sup>; the average number of taxa per sample was 0.9 per 0.05 m<sup>2</sup>. Thirty-two distinct taxa were collected from this habitat type, which was second only to the abandoned channels (39 distinct taxa). The mixed lotic and lentic composition of the taxa collected indicate that, for this sampling period, a characteristically distinct benthic macroinvertebrate assemblage did not occur within this habitat type. Based on the high abundance of lentic-adapted taxa collected from this habitat, it was hypothesized that certain of these dike fields may serve as secondary sites for the origin of drifting invertebrate organisms (principally lentic) during periods of lower river stage when pool formation occurs within these dike fields. In this sense, the dike fields may serve as an extension of abandoned channels under low flow conditions when the majority of abandoned channels are totally isolated from the main channel aquatic ecosystem.

46. Based on the pilot studies, three aquatic habitats within the

area were characterized by distinct benthic macroinvertebrate assemblages. These included abandoned channels, characterized by a lentic assemblage composed primarily of oligochaetes, dipteran larvae, and fingernail clams; natural banks, characterized by a lotic assemblage composed primarily of unique burrowing mayflies and clinging macroinvertebrates (principally caddisflies); and dike (and possibly ACM revetment) structures, characterized by a lotic assemblage composed primarily of net-spinning caddisflies, tube-building chironomid larvae, and clinging mayflies. The key to the habitat value of these three habitats for benthic macroinvertebrates appears to be habitat (substrate) stability. The remainder of the habitats sampled (dike fields, main channel, sandbars, permanent and temporary secondary channels) were primarily characterized by shifting, unstable coarse sand and gravel sediments. The mixed and highly diverse lotic and lentic composition of these assemblages and the predominance of these assemblages within microdepositional zones within each habitat indicate that their origin is primarily from main channel macroinvertebrate drift, principally originating in turn from abandoned channels, natural banks, and dike structure habitats.

47. Based on this scenario, abandoned channels, natural banks, and dike structures might be construed as the primary sources for the origin of drifting macroinvertebrates within the study area (Table 3). The remainder of the habitats sampled (or more appropriately, microdepositional sites within each habitat) might be construed as recipient habitats for these drifting macroinvertebrates. Although these microdepositional sites are highly transient in nature and their size and areal extent changes continuously with river stage, the zones may be ecologically important to the riverine fishery, particularly for feeding purposes.

#### Report 4: Diel Periodicity of Benthic Macroinvertebrate Drift

48. Studies of the benthic drift were carried out in conjunction with those of benthic macroinvertebrates. Primary emphasis was placed upon the determination of the most cost-effective and technically

correct sampling rationale. This was carried out by investigating:

- a. The taxa comprising the drift.
- b. Those taxa predominating, by number, the drift and the relative abundance of those taxa.
- c. Diel changes in relative abundance of drift.
- d. Relative contribution of the various habitat types to the stream drift.

49. Drift samples were collected by towing 0.5-m (mouth diameter) conical plankton nets of 505- $\mu$ m mesh netting equipped with a General Oceanic Model 2041 digital flowmeter. Surface tows (of approximately 0.5-m depth) were taken with two nets towed simultaneously downstream, one on each side of the sampling boat. Five sets of duplicate tows were collected during each of five intervals during the diel period: 1200 hr (noon), 1600 hr (afternoon), 2100 hr (dusk), 0100 hr (midnight), and 0600 hr (dawn). Fifty samples were collected, washed from the nets, and preserved onboard with 5-percent buffered formalin.

50. The 49 samples analyzed (one was lost in transit) contained 5090 individuals from 80 taxa. The colonial hydriod Cordylophora sp. was the most numerically dominant species with 150 to 300 zooids per sample. Because the zooids per specimen were highly variable and often macerated, Cordylophora sp. was not included in the analyses. Two taxa, Hydra sp. (Cnidaria) and Hydropsyche spp. (Trichoptera), comprised 26 and 29 percent, respectively, of the total number of organisms. Potamyia flava (Trichoptera), Chaoborus sp. and Polypedilum spp. (Diptera), Tortopus incertus and Pentagenia vittigera (Ephemeroptera), Diptera pupae, and terrestrial Coleoptera comprised 29 percent, and the other 16 percent of the total number was composed of the remaining taxa.

51. Total density of drifting macroinvertebrates averaged 140.8 organisms/100 m<sup>3</sup> with a standard deviation of 47.6 organisms/100 m<sup>3</sup> over the 49 samples. The average total densities of drift per period did not exhibit pronounced or well-defined day-night fluctuations (Figure 4). However, differences in average total densities were significant ( $p < 0.05$ ). The dawn (0600 hr) sampling period had a lower average density than the other four periods; however, there was no significant

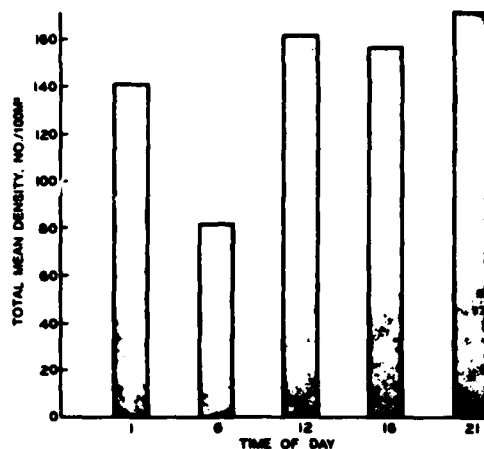


Figure 4. Total mean densities of macroinvertebrates at different times

difference among averages for the latter periods.

52. The average number of taxa per 100 cubic metres of water filtered (diversity) was 12.08 with a standard deviation of 2.704. It varied significantly ( $p < 0.05$ ) over the diel period (Figure 5). Drift diversity was greatest during dusk, midnight, and dawn, in that order and was lowest at noon; the average number of taxa per 100 cubic metres of water filtered was significantly ( $p < 0.05$ ) less for the noon and afternoon sampling periods than for the remaining periods. Diversity was significantly less at dawn than at dusk. Diversity did not differ significantly ( $p < 0.05$ ) from dusk to midnight, nor from midnight to dawn.

53. Of the 80 taxa contributing to the stream drift, 9 taxa contributed 84 percent of the total number of organisms. Hydropsyche spp. was the most dominant comprising 29 percent of the total drift numbers, while Hydra sp. contributed 26 percent. Other dominant taxa and their percentage composition were: Potamyia flava, 7 percent; Diptera pupae, 7 percent; Chaoborus sp., 6 percent; Tortopus incertus, 4 percent; Pentagenia vittigera, 3 percent; Polypedilum spp., 2 percent; and terrestrial Coleoptera, 1 percent.

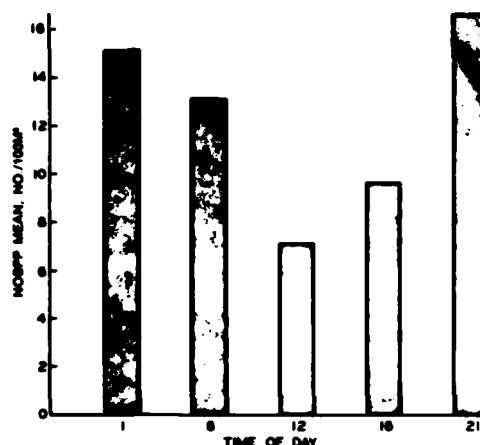


Figure 5. Mean number of species at different times

54. The greatest number of species, the greatest total number of organisms, and the greatest number of Hydropsyche spp. and terrestrial Coleoptera drifted at dusk. The greatest numbers of Tortopus incertus, Pentagenia vittigera, Potamyia flava, and Diptera pupae drifted near midnight, while the greatest number of Polypedilum spp. drifted in the afternoon and greatest number of Hydra sp. drifted at noon.

55. In summary, differences in the abundance of the nine most abundant species were noted. Five species were found to be most abundant at midnight, two species at dusk, and one, respectively, at noon and afternoon. This information provided guidance concerning the potential sampling bias associated with each sampling period.

56. The various habitats, such as swift-water dike and revetment areas, natural claybanks, and riverine backwaters (slack-water lentic conditions) with silt, clay, and sand sediments, were well represented in the drifting benthos through the preferred-habitats association. The closest (to the sampling area) and a very dominant habitat, swift-water revetted bank, was represented by Hydropsyche spp. and Potamyia flava; they are also dominant dike representatives. Dikes were well represented by Polypedilum spp. and other species. Natural clay banks were represented by Tortopus incertus and Pentagenia vittigera, and slack-water areas were represented by a variety of taxa including

Chaoborus sp. and Diptera pupae. However, many Diptera pupae are not confined to slack-water areas, though they are generally abundant there. The preferred habitat of Hydra sp. has yet to be established.

#### Report 5: Fish Studies--Pilot Report

57. Studies of adult fish were conducted in nine major habitats to evaluate sampling gear and obtain an initial estimate of the kinds and numbers of fish in the habitats. A tenth habitat (inundated floodplain) was also sampled but no useful results were obtained. The nine major habitats are discussed below in order of decreasing diversity.

58. Dike fields had the most diverse fish community. The 55 species collected in dike fields included 10 species unique to this habitat. These were the stoneroller, cypress minnow, pugnose minnow, spotfin shiner, steelcolor shiner, creek chub, black buffalo, blackstripe topminnow, longear sunfish, and spotted bass. Gizzard shad, Mississippi silverside, threadfin shad, black crappie, and freshwater drum were the five most frequently collected species.

59. Although areas of standing and flowing water with different substrates were present, the general diversity of habitat was considerably less in sandbars than in dike fields. Also, the variety of gears used and the number of samples collected were reduced when compared with the effort in the dike fields.

60. Thirty-nine different species of fish were collected with gill nets, hoop nets, and seines. Two species, the bluntnose darter and the speckled chub, were captured only from this habitat. The five most frequently collected species, in decreasing order, were gizzard shad, Mississippi silverside, river shiner, freshwater drum, and river carpsucker.

61. The high diversity observed in sandbar habitat seems largely attributable to fish collected from shallow shoreline water with seines. Considerably more species were collected at the more extensively seined sites. Relative to the number of species caught with the same gear in other habitats, high numbers of species were collected with hoop nets.

Only moderate numbers of species were collected with gill nets. However, the gill nets were only fished for two net-nights.

62. The third highest diversity of fish was collected in abandoned river channels. The high diversity in the abandoned channels is significant because only gill nets, trammel nets, hoop nets, and slat traps were fished; almost all fish were caught in the web nets. Of the gears used, 8-ft gill nets caught a greater number of species in the abandoned channels than were caught in the other habitats with this gear. Thirty-one species of fish were collected from the sites in this habitat. Of these species, two were collected only from this habitat--brown bullhead and warmouth. Gizzard shad was the most frequently collected fish, followed by river carpsucker, freshwater drum, carp, and shortnose gar.

63. Only hoop nets and seines were used to collect fish in the temporary secondary channel. Twenty-eight different species were collected. No species was unique to this habitat. Mississippi silverside was the most frequently collected species. River shiner, gizzard shad, white bass, and threadfin shad were the second through fifth most frequently collected species.

64. Twenty-seven species of fish were captured in the oxbow lake; no species was unique to this habitat. Gizzard shad was the most frequently collected species. River carpsucker, freshwater drum, channel catfish, and white crappie were the second through fifth most frequently collected species.

65. Hoop nets and electroshocking were the only fish-capture device/techniques that could be deployed in the swiftly flowing waters along the revetted banks. These gears caught 18 different species. No species unique to revetted banks was captured. Freshwater drum was the most abundant species in this habitat type, followed by channel catfish, gizzard shad, flathead catfish, and blue catfish.

66. Hoop nets and electroshocking were used to sample fish along natural banks. These gears caught 19 different species. No species was unique to natural banks. Freshwater drum were caught most frequently. Flathead catfish, carp, gizzard shad, and blue catfish were the second through fifth most numerically abundant in the catch.



67. The sixth and seventh greatest numbers of species were collected at the revetted bank and natural bank habitats, respectively. The number of species collected in these two habitats was similar, as was expected, because of the similarity of the two habitats, the use of the same gears, the similar time of sampling, and the geographical proximity of the revetted bank and natural bank areas. The lower diversity of the fish communities in these habitats, compared to the diversity found in other habitats, is associated with the limited habitat diversity and the types of gear that could be fished in these areas.

68. Only one borrow pit was sampled during the pilot study. The borrow pit habitat is very similar to the other standing-water habitats, except that the borrow pit is smaller and not generally confluent with the river. Sampling was conducted with gill nets and a seine. Thirteen species of fish were collected. Of the few fish caught, river shiner was the most abundant species, followed by spotted gar and bowfin in equal numbers.

69. Sampling with trammel nets and hoop nets in a permanent secondary channel yielded 12 species of fish. No species of fish unique to this habitat was collected. Freshwater drum, carp, flathead catfish, channel catfish, and shovelnose sturgeon, in decreasing order, were the four most frequently collected species. Fewer species were collected than at the natural banks and the revetted banks. The permanent secondary channel, natural bank, and revetted bank samples are similar because most of the samples were collected with hoop nets along steep bank areas. The lower diversity in the permanent secondary channel was, therefore, unexpected. Further, the low diversity is surprising because some sampling was conducted with trammel nets.

70. Because different types of sampling gear were used in the various habitats, direct comparisons of abundance are most difficult. However, it is possible to make comparisons between fish abundance in various communities.

71. Based on species composition and relative numerical frequency of species collected, three generalized fish communities can be recognized. There is a diverse standing-water community typified by the fish

collected in the abandoned channels and oxbow lake. Shortnose gar, gizzard shad, carp, river carpsucker, channel catfish, white crappie, and freshwater drum are numerically dominant; paddlefish, spotted gar, black bullhead, yellow bullhead, and brown bullhead are unique to the standing-water community. The standing-water community, except for its unique species, also occurred in dike fields, primarily in the slack-water areas. The borrow pit is also a standing-water habitat but, based on the low diversity collected (albeit with limited sampling), may represent a unique community.

72. The flowing-water community is typified by the moderately diverse communities along natural and revetted banks. Gizzard shad, carp, blue catfish, channel catfish, flathead catfish, and freshwater drum are numerically dominant; shovelnose sturgeon, goldeye, mooneye and spotted sucker are rather unique in this flowing-water community. This community also occurred in the dike field, sandbar, temporary secondary channel, and permanent secondary channel habitats.

73. Another community consists of the inshore fish. This is a diverse community of fish seined in the shallow, near-shore habitats of dike fields, natural sandbars, and temporary secondary channels. Frequently collected inshore species included the various Notropis spp., bullhead minnow, river carpsucker, buffalo, brook silverside, Mississippi silverside, white bass, striped bass, and young-of-the-year sunfish.

74. Numerical catch per unit of effort (C/f) was used as an index of abundance for the fish communities. For most gear types in most habitats, C/f was highly variable. C/f varied over time, between habitats and within sites within a habitat. Also, equal units of effort could be standardized to allow more meaningful comparisons of diversity and relative abundance. Considering the wide variations in C/f, the standing-water fish community was most abundant in abandoned channels and the oxbow lake. C/f in flowing water was highest in the chute connecting Lake Lee with the river. The flowing-water fish community was collected in similar abundance from the natural bank, revetted bank, dike field, sandbar, and temporary secondary channel habitats, with the temporary secondary channel habitat exhibiting the greatest abundance.

75. Overall, 66 species of fish were collected with gill nets, trammel nets, hoop nets, trawls, seines, slat traps, and electroshocking. The dike fields were the most diverse habitat type, where 55 species of fish were collected. The following habitats are listed in descending order according to their species diversity: natural sandbar (39 species), abandoned channel (31 species), temporary secondary channel (28 species), oxbow lake (27 species), revetted bank (18 species), natural bank (19 species), borrow pit (13 species), permanent secondary channel (12 species), and inundated floodplain (1 species). Ten species of fish were collected in dike fields only and nowhere else. Other habitats with unique species were the sandbar (2 unique species) and the abandoned channel (2 unique species).

76. Various types of fish collection gear were evaluated during the pilot investigations. In the standing-water community, gill nets were found to be the most effective collection device. Hoop nets and electrofishing were equally effective in the flowing-water community. Repetitive electrofishing demonstrated that this technique yields very low sample variance. In the shallow shoreline area, seines were most effective except where there were numerous obstructions and snags. To sample smaller fish effectively in such obstructed areas, collapsible cloth traps (Figure 6) were fabricated to eliminate weight and bulk problems associated with conventional wire-mesh minnow traps.

77. Data analysis also indicated that the same habitat type should be sampled at two or more locations to determine variance (representativeness of sample). Differences in species diversity through time were noted in the standing-water community (greatest in June) and flowing-water community (greatest in April through June), but not in the shallow shoreline community. This suggests that different levels of effort are desirable in sampling the diversity of these three fish communities.

78. Based on diversity and abundance, abandoned channels, oxbow lakes, revetted banks, natural banks, dike fields, and sandbars appear to be very important in the maintenance of riverine fish communities. Dike fields are of particular interest because all three fish communities



Figure 6. Collapsible cloth trap  
for small fish

(flowing water, standing water, and shallow shoreline) are well represented within them.

#### Report 6: Larval Fish Studies--Pilot Report

79. Nine habitats were sampled for larval fish. In contrast to the fish studies, where a variety of gear types was used, only a 0.5-m-diameter plankton net with 505- $\mu$ m mesh was used for larval fish. This gear is in common use for larval fish and was selected to improve comparability of the data to that obtained by other researchers. The findings are discussed below in order of decreasing abundance of larval fish at each habitat.

80. The abandoned channel and oxbow lake habitats appeared to support similar larval fish populations. Representatives of five families were collected in both habitats: Clupeidae, Atherinidae, Percichthyidae, Centrarchidae, and Sciaenidae. Clupeids and centrarchids were the predominant taxa in both habitats. Aplodinotus grunniens

(freshwater drum), common or abundant in all other habitats except sandbars, was rare in both abandoned channels and oxbow lakes.

81. Menidia audens and Morone spp. were common in the abandoned channel habitat and rare in the oxbow lake habitat. Carpionodes spp. was rare in the abandoned channel habitat and not collected in the oxbow lake habitat. It appears that spawning or nursery conditions are more favorable for these three taxa in the abandoned channel.

82. Cyprinidae and Pomoxis spp. were collected only in the oxbow lake habitat. These taxa were collected in a chute connecting the lake with the river. This station was located in flowing water; whereas, the other two oxbow lake sampling stations and both stations in the abandoned channel were standing water or very slowly flowing water. This suggests flowing-water habitats are more favorable spawning or nursery areas for these two taxa.

83. Dorosoma spp. and D. petenense were collected in the oxbow lake, but were not collected in the abandoned channel. However, since identification of clupeid larvae to genus and species requires advanced stages, the same clupeids may have been present in both habitats, while more advanced clupeids were collected only in the oxbow lake.

84. Natural banks exhibited a relatively high diversity of larval fish. Eight families were collected: Clupeidae, Hiodontidae, Cyprinidae, Catostomidae, Percichthyidae, Centrarchidae, Percidae, and Sciaenidae. This was the only flowing-water habitat where clupeids were abundant. Sciaenids were abundant only in the natural bank and revetted bank habitats, both of which are flowing-water habitats. Cyprinids were common at natural banks, revetted banks, and dike fields. Catostomids were common only at natural banks and sandbars. Centrarchids, common at natural banks, were also common at oxbow lakes, revetted banks, and dike fields. It is interesting to note that natural banks, revetted banks, sandbars, dike fields, and oxbow lakes are all aquatic habitats that provide shelter from main channel flows. Hiodontids, however, were common at natural bank, dike field, and permanent secondary channel and revetted bank habitats. The data indicate that natural banks are an important habitat

for larval clupeids, hiodontids, cyprinids, catostomids, centrarchids, and sciaenids.

85. Revetted banks showed a high diversity of larval fish. The eight families of larval fish collected at the natural bank habitat plus Atherinidae were collected here, indicating similarity to the natural bank habitat. The abundance of Aplodinotus grunniens and the common occurrence of hiodontids, cyprinids, and centrarchids further indicate the similarity between revetted banks and natural banks. Clupeids and catostomids were, however, more abundant at natural banks than at revetted banks. Revetted banks were the only habitat where Alosa chrysochloris was collected. Micropterus spp. was collected only at revetted banks and dike fields. The data indicate that revetted banks are an important habitat for larval clupeids, hiodontids, cyprinids, centrarchids, and sciaenids.

86. The main channel habitat was characterized by a relatively low diversity of taxa. Three of the four main channel stations had relatively low densities of larval fish with Aplodinotus grunniens the most numerically abundant taxon. In addition to A. grunniens, clupeids, Carpiodes spp., and unidentified centrarchids were collected in the main channel.

87. The density of larval fish was relatively low, and the diversity of taxa was intermediate in the permanent secondary channel and was similar to the main channel, which would be expected since both habitats are open, flowing-water habitats. As in the main channel, Aplodinotus grunniens and Clupeidae were the most abundant taxa, constituting over 68 percent of the individuals collected. However, larval fish were first collected during mid-April, earlier than at most main channel stations, but at the same time as at the natural bank stations.

88. In the temporary secondary channel the density of larval fish was relatively low, but diversity of taxa was high. This habitat is similar to the main channel, except for the generally reduced velocity of currents. Therefore, densities similar to the main channel and the high frequencies of Aplodinotus grunniens and Clupeidae were not unexpected. An important difference between the temporary secondary channel

and the main channel is that a large portion of the water flowing through the temporary secondary channel passes through one or two dike fields. The dike fields generally have a diverse larval fish fauna and, therefore, may account for the relatively high diversity of taxa encountered in the temporary secondary channel. Larval fish collected during mid-April shows similarity with dike fields, supporting the possible contribution of the dike fields.

89. The dike field habitat is characterized by relatively low mean densities of larval fish and a high diversity of taxa. All families of larval fish collected during this entire study were represented in the dike fields, including Lepisosteidae, which was collected only in dike fields and in the sandbar habitat. An interesting aspect of the diversity in the dike fields is that the taxa collected in the standing-water habitats and the main channel type habitats were all represented in the dike field habitat, but the abundances of the various taxa show the strongest similarity to the riverbank habitats (natural bank and revetted bank). For example, clupeids were abundant and common at natural and revetted banks, respectively, and common in the dike field; hiodontids, cyprinids, and centrarchids were common in natural bank, revetted bank, and dike field habitats; and percids were collected only in these three habitats. The most notable exception to the similarity among these three habitats is that Aplodinotus grunniens was abundant at natural and revetted banks, but was only common in the dike field habitat.

90. Clupeidae and Sciaenidae were the only two taxa collected in all dike fields. Hiodon alosoides, Cyprinidae, and Centrarchidae were collected at five of the six dike field stations. Dorosoma cepedianum, Cyprinus carpio, and Ictiobus spp. were collected at four of the six dike field stations.

91. The density of larval fish and diversity of taxa were low at the towhead sandbar habitat. This was the only habitat where Cyprinidae was the most abundant taxon; however, the seven taxa collected here were approximately equal in relative abundance compared to other habitats. Ictalurus punctatus was collected only here and at one dike field. The low

density and diversity of larvae indicate generally that this flowing-water sandbar habitat is a poor spawning or nursery area for fish.

92. The information obtained on larval fish during the pilot investigations indicated that a number of habitat types could be paired on the basis of both abundance and number of species (Table 4). Abandoned channels and oxbow lakes ranked first in abundance and fourth in number of species, but dike fields exhibited a converse relationship. It is of interest that, in common with the findings of the fish studies, all families of larval fish collected during the sampling interval were represented in the dike field habitat.

93. As with benthic drift, studies of the diel periodicity of larval fish were conducted at midnight, dawn, noon, afternoon, and dusk. Unlike the benthic drift, both the greatest abundance and diversity were found to occur at a single time. Hence, when time or resources for sampling are limited, a definite possibility exists for the opportunity to obtain a maximum amount of information on larval fish with a minimal sampling effort by sampling at dusk. This assumes a relatively small number of sampling stations that could be sampled over a short time.

94. It was also found that spawning, and thus the occurrence of larval fish, took place over an extended period. Thus, no brief seasonal sampling period could be defined that would provide a complete assessment of the diversity and abundance of fish in the pilot area.

#### Report 7: Management of Ecological Data in Large River Ecosystems

95. It was recognized that the long-term studies following the pilot investigation would generate large volumes of data. Typically, these multiple data bases would have been composed of hierarchical file structures with a high probability of error propagation into summary reports. With studies that substitute numeric codes for variable values, the problem of error propagation is even more serious.

96. Several approaches are available to minimize errors in coding variables. These are so-called "smart" and "nonsense" codes. In the former, difficulty is encountered when there are variables with many



values and/or levels of classification because full knowledge is required (of the range) that the variables describe as well as potential classification schemes for each variable. Consequently, nonsense codes, which do not have embedded information, were used to avoid the problems associated with smart codes. The fish studies provide an illustrative example.

97. Of over 2000 fish species found in the United States, it was estimated that, at the minimum, the complete taxonomy for 200 species would have to be coded to ensure that a high percentage of those expected to occur in the study area would be included. Even so, a high probability existed that several uncommon (or "new") species might be encountered. With a smart code this would have required leaving (strategic) gaps in the system to accommodate these unknowns. An additional requirement of the system was to provide for at least 10 to 15 ecological variables (e.g., trophic level, sexual condition, age, growth stage, etc.) for subsequent summary analyses. Little information was available concerning the appropriate values and extensive literature searches would have been required for some (if, indeed, the knowledge existed at all).

98. In the pilot investigation, nonsense codes were used for fish species. A sequential numeric code beginning with 101 was given to each species as it was discovered in the field with no adjustments with regard to taxonomic position. Some 146 species were ultimately collected and coded into the system. It is of interest that, of the original 200 species anticipated to have been present, less than 75 percent were actually found. Of more importance was the occurrence of six species that would not have been coded into the original 200; inserting these into a smart coding scheme might have been a minimal effort if the appropriate gaps had been left in the code structure. Foresight to leave such gaps would have been unlikely.

99. Although a detailed analysis of error reductions was not conducted, it appears that the use of nonsense codes may have reduced error frequency in the order of 10 to 30 percent over that encountered with conventional smart codes. One reason for this may be the simplification of the recording process through the removal of correlative

classification levels. In addition, no subject-area skills are required of the recorder when using nonsense codes because a hierarchical code identification is not needed. Rather, only the assignment of a simple accession number is required.

### PART III: CONCLUSIONS

100. Habitat mapping proved to be a most useful technique in study design. The habitat approach also provided a valuable framework for the portrayal and interpretation of data. Through knowledge of the acreage of the various habitats at different river stages and their relative importance as ecosystem components, insight was gained on the possible environmental impacts of CE activities.

101. The benthic analyses provided guidance on appropriate experimental design and sampling methods for the various habitats. It was found that no appropriate technique existed for revetted banks. Analysis of the biological data indicated that abandoned channels, natural banks, and dike structures function as sources for the origin of drift organisms with the other habitats primarily being receivers.

102. Studies of drift organisms indicated a distinct diel periodicity with regard to abundance and diversity. This led to the development of a sampling rationale which minimized effort (and costs) while maximizing the amount of information obtained.

103. The fish studies evaluated a variety of sampling gears. It was found that, through appropriate gear selection, the fish fauna of most habitats could be adequately evaluated. Important differences in species composition and abundance were noted in the habitats with dike fields being of special interest because of the diversity of habitats found within them. Examination of species composition and relative abundance indicated that three fish communities were present. These were the standing-water, flowing-water, and shallow-shoreline communities.

104. As with benthic drift, there were significant diel differences in the diversity and abundance of larval fish. Knowledge of these differences allowed the development of the most effective and efficient sampling scheme. Analysis of the data indicated that, based on the diversity and abundance of larval fish, a number of habitats could be paired.

105. To handle the large volume of data generated during the pilot

study and the even larger volume expected from the full-scale effort, nonsense codes were utilized. It was felt that this approach reduced the error frequency by 10 to 30 percent over that found with smart codes.

Table 1  
Surface Acreage of Aquatic Habitats at Three River  
Stages in the Pilot Investigation Area

No.	Habitat Type	Low Flow (18 Jun 76)		Medium Flow (5 Dec 78)		High Flow (18 Dec 78)	
		Acres	%	Acres	%	Acres	%
1	Main channel	8,435	45	8,435	29	8,435	15
2	Natural banks	166	1	281	1	448	1
3	Revetted banks	842	5	1,536	5	1,791	3
4a	Sandbar slack-water pools	101	1	0	0	0	0
4b	Natural sandbars	962	5	2,397	8	6,285	11
5a	Dike field pool areas	311	3	600	2	0	0
5b	Dike field sandbars	848	5	7,393	26	10,441	18
6	Permanent secondary channels	530	2	630	2	630	1
7	Temporary secondary channels	708	4	990	3	2,553	5
8	Abandoned channel (Type I)	801	4	1,424	5	2,230	4
9	Abandoned channel (Type II)	1,860	9	1,860	7	1,860	3
10	Oxbow lakes	2,191	12	2,309	8	2,309	4
11	Borrow pits	826	4	1,165	4	4,798	8
F	Inundated floodplain	0	0	0	0	15,122	27
Totals		18,581	100	29,020	100	56,902	100
Average acres of habitat per river mile		372		580		1,138	

Table 2  
Summary of Benthic Macroinvertebrate Data Collected from the  
Nine Aquatic Habitats, June 1978

Habitat	Total Organisms Collected	Avg Density per Sample*	Total Distinct Taxa Collected	Avg Number of Taxa/Sample	Habitat Sampler Type
Dike fields	1,623	7.4	32	0.9	Ponar grab; Shipek grab
Dike structures	10,726	536.4	28	7.3	Individual stones by hand
Revetted banks	126	0.6	15	0.3	Shipek grab
Natural banks	1,011	9.4	26	1.4	Shipek grab
Abandoned channels	7,004	70.04	39	5.2	Ponar grab
Permanent secondary channel	3	0.3	3	0.3	Shipek grab
Temporary secondary channel	51	2.1	14	1.0	Shipek grab
Main channel	9	0.5	6	0.5	Shipek grab
Sandbars	12	1.5	7	1.0	Shipek grab

\* All grab sample data are standardized to number per 0.05 m<sup>2</sup>.

Table 3  
Abundance and Diversity of Benthic Invertebrates  
Collected During the Pilot Investigation

	<u>Avg Density per Sample*</u>	<u>Total Distinct Taxa Collected</u>
Contributors:		
Dike structures	536.4	28
Abandoned channels	70.04	39
Natural banks	9.4	26
Receivers:		
Dike fields	7.4	32
Temporary secondary channel	2.1	14
Sandbars	1.5	7
Revetted banks	0.6	15
Main channel	0.5	6
Permanent secondary channel	0.3	3

\* All grab sample data are standardized to number per 0.05 m<sup>2</sup>.

Table 4  
Relative Abundance and Diversity of Larval Fish  
Collected During the Pilot Investigation

<u>Habitat</u>	<u>Ranking for Abundance</u>	<u>Ranking for Number of Taxa</u>
Abandoned channels/oxbows	1	4
Natural banks/revetted banks	2	2
Main channel/perm. secondary channel	3	3
Dike fields	4	1

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Wright, Thomas D.

Aquatic habitat studies on the Lower Mississippi River, River Mile 480 to 530 : Report 8 : Summary / by Thomas D. Wright (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1982.

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